Work in-progress:
Optical Model and Flash Matching in MicroBooNE

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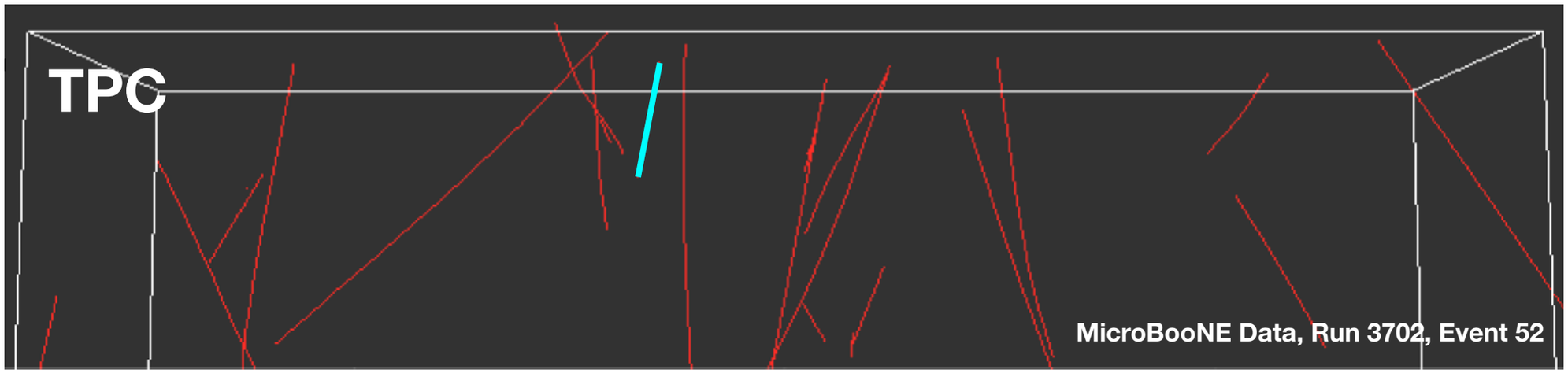
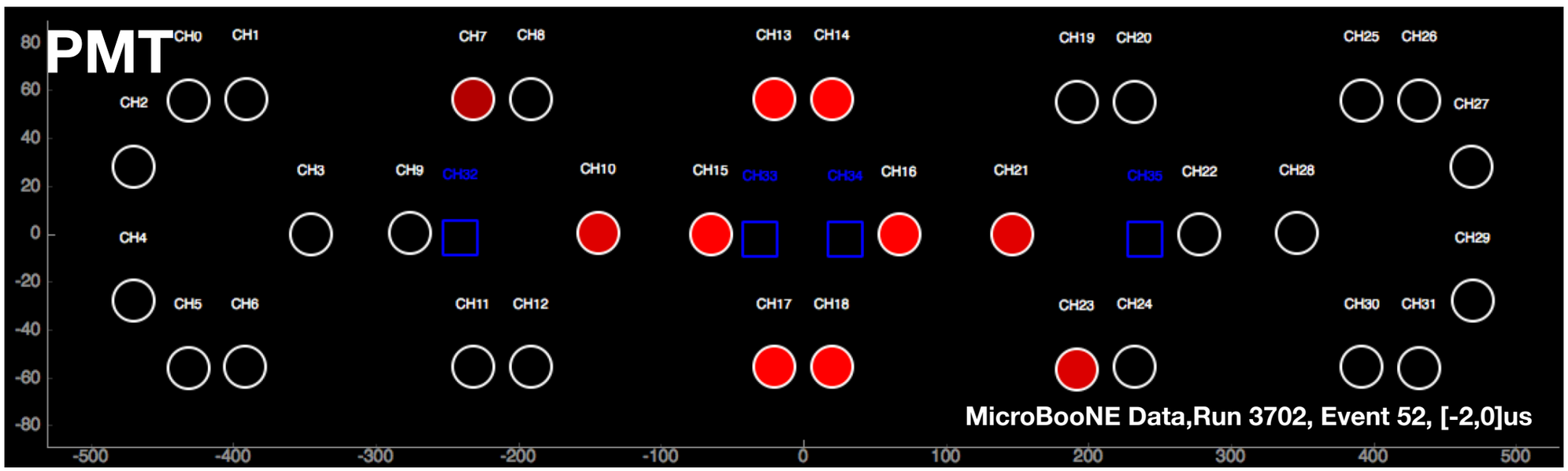
Optical Model and Flash Matching in MicroBooNE

- Interactions in MicroBooNE have two types of data streams, **TPC** and **optical** products. These two need to be matched in the final state.

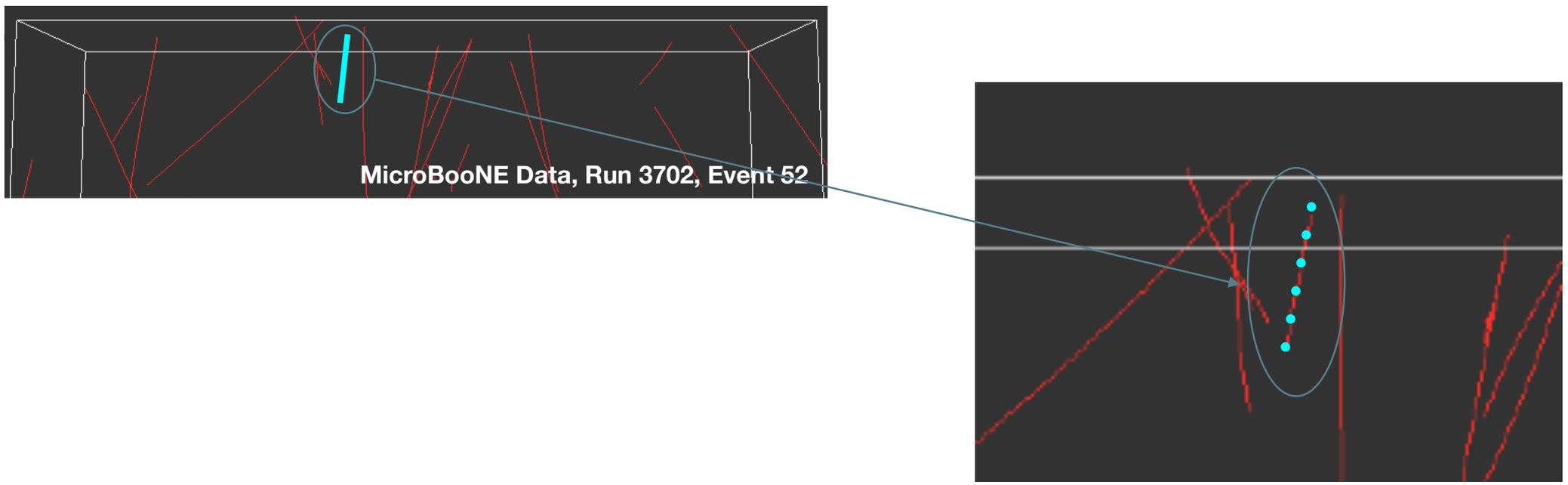
- To do this flash track matching, we translate TPC object into optical object using light prediction algorithm.





Light Prediction

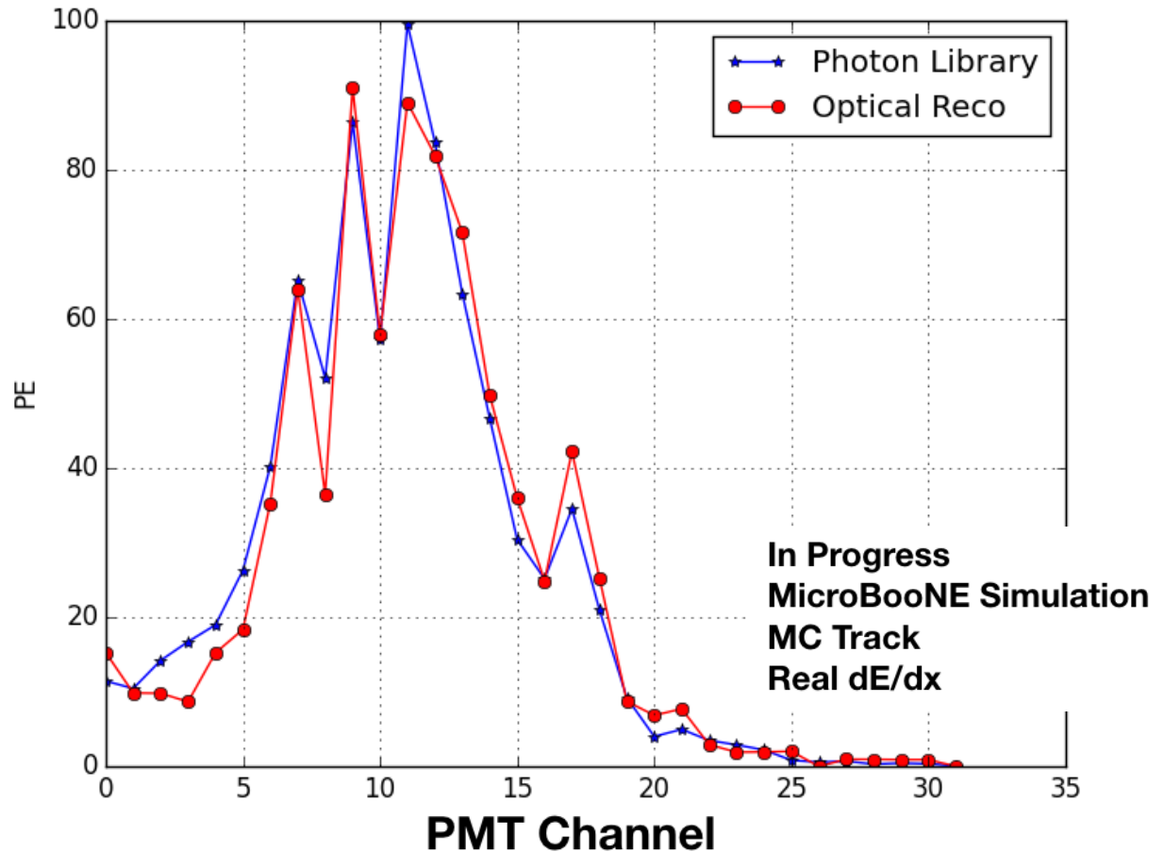
- Algorithms have been developed to treat MC and reconstructed tracks respectively. MC track here refers to truth track in simulation knowing deposited energy at each trajectory point,
- In these algorithms, tracks are divided into small segments and translated into charged 3D trajectory points carrying scintillation photons associated with them.
- For MC track, number of scintillation photons is calculated with real dE/dx using truth level information about deposited energy at each point. For reconstructed track we assume all the muons are MIP(minimum ionizing particle).



Light Prediction —MC Track

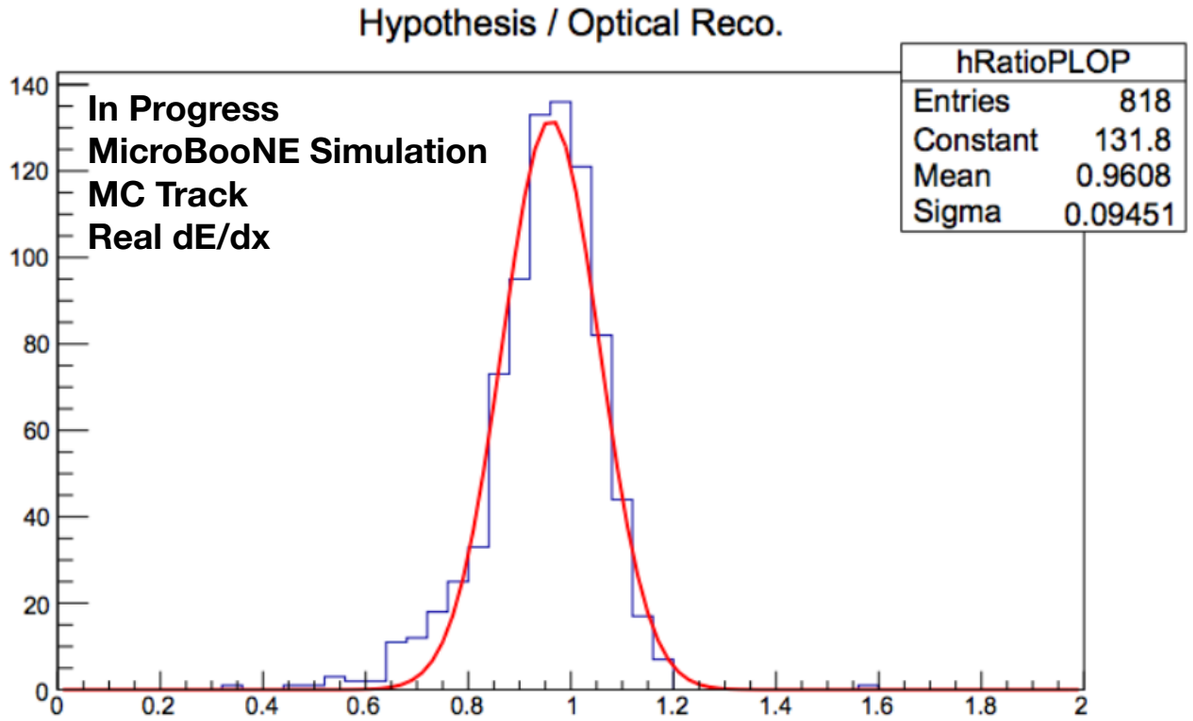
- Optical simulation further combines and translates charged points into PE(photo electron seen by each tube) distribution across PMT.

- One example to show this translation:
  363 MeV single muon, spectra from prediction and optical reconstruction overlay very well and the ratio of total amount of light from hypothesis and optical reconstruction is 1.02



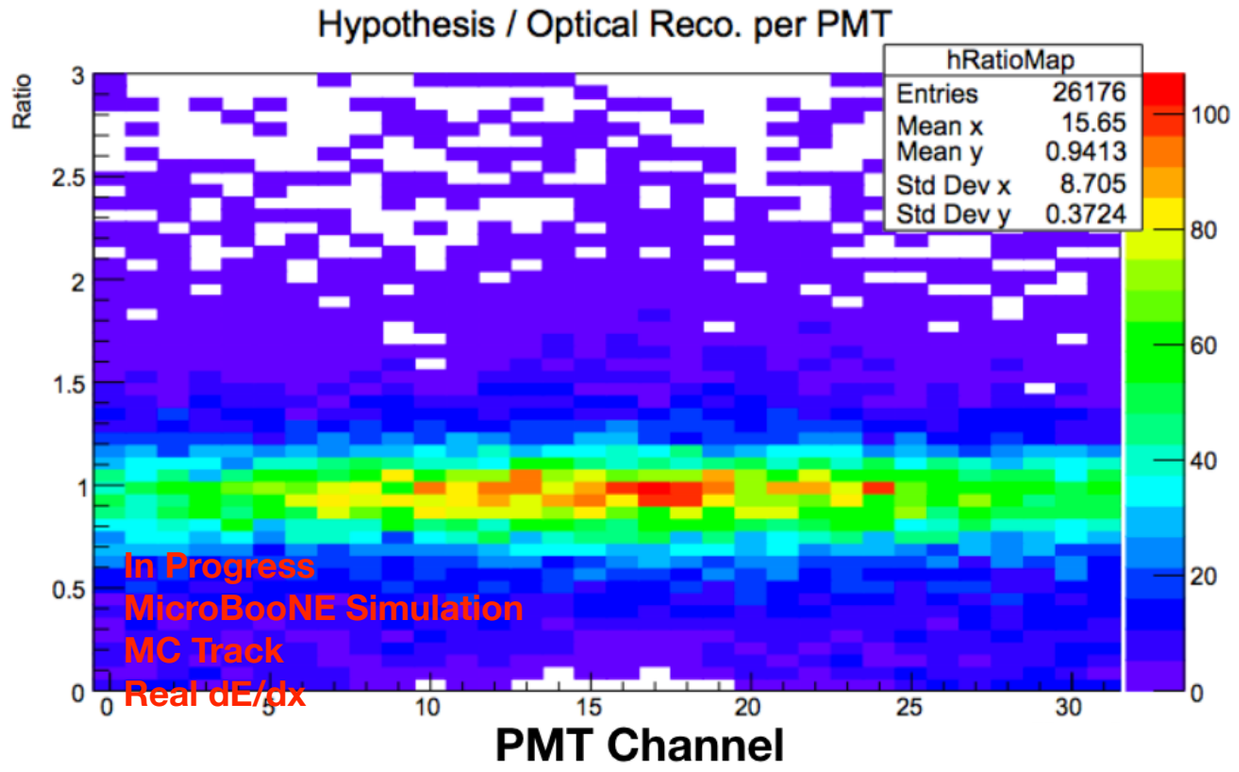
Light Prediction —MC Track

- Factor in light predictions between MC track and reconstructed tracks are disentangled into two:
  (1)Deviation between real dE/dx calculated in MC and MIP in reconstructed tracks
  (2)Inefficiency introduced by track reconstruction



- Comparisons: We do two comparisons to evaluate the performance of light prediction:
  Top: ratio of total amount of light between hypothesis and optical reconstruction;
  Bottom: scan of comparisons across all PMT channels,

- By looking at the distributions, we can see factor of utilizing Mip instead of real dE/dx is negligible.



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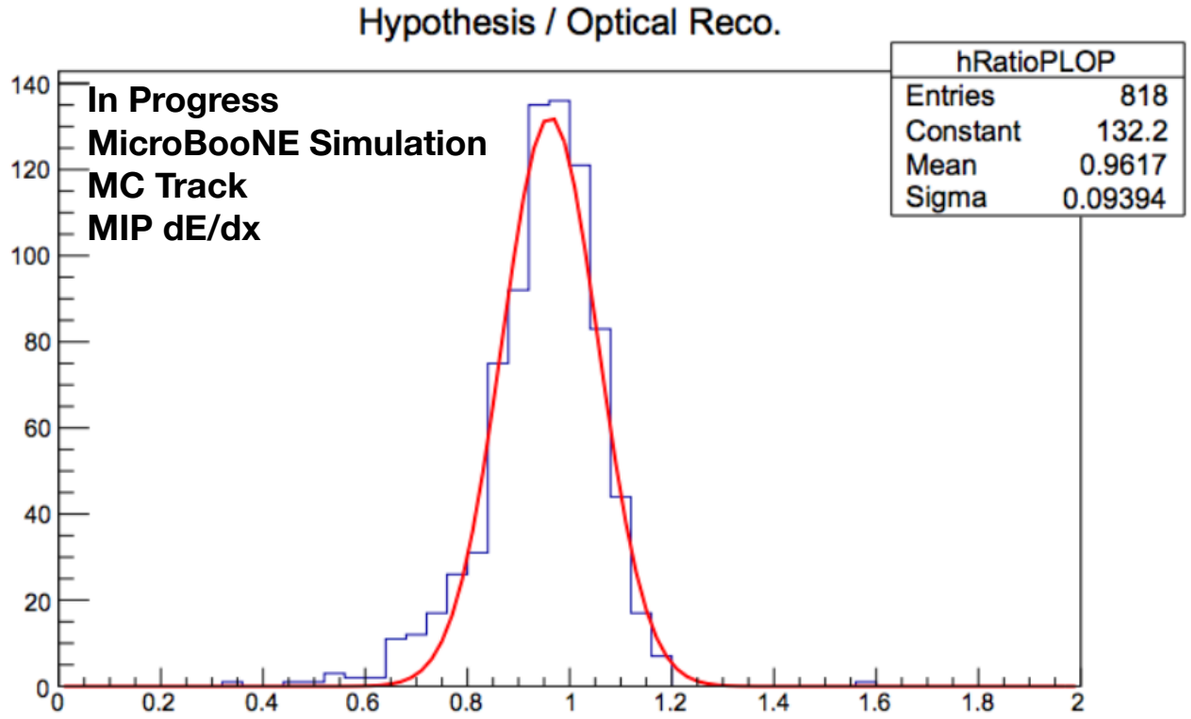

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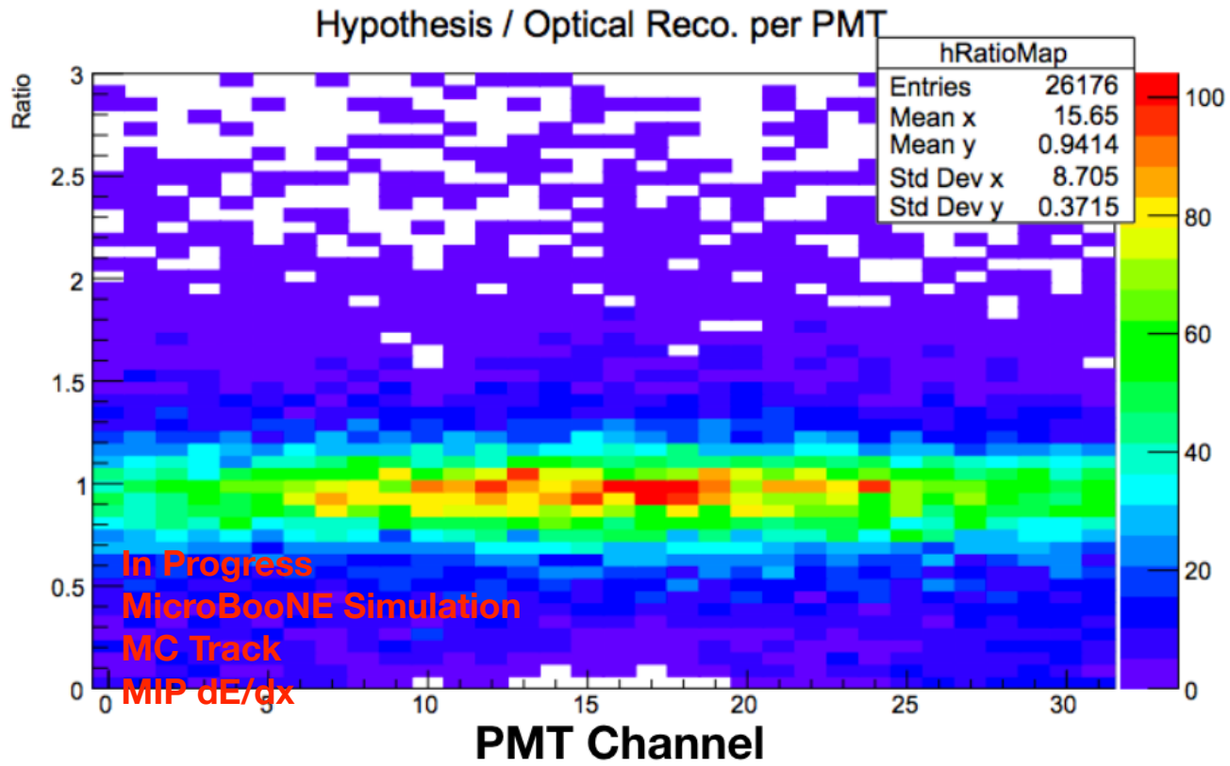


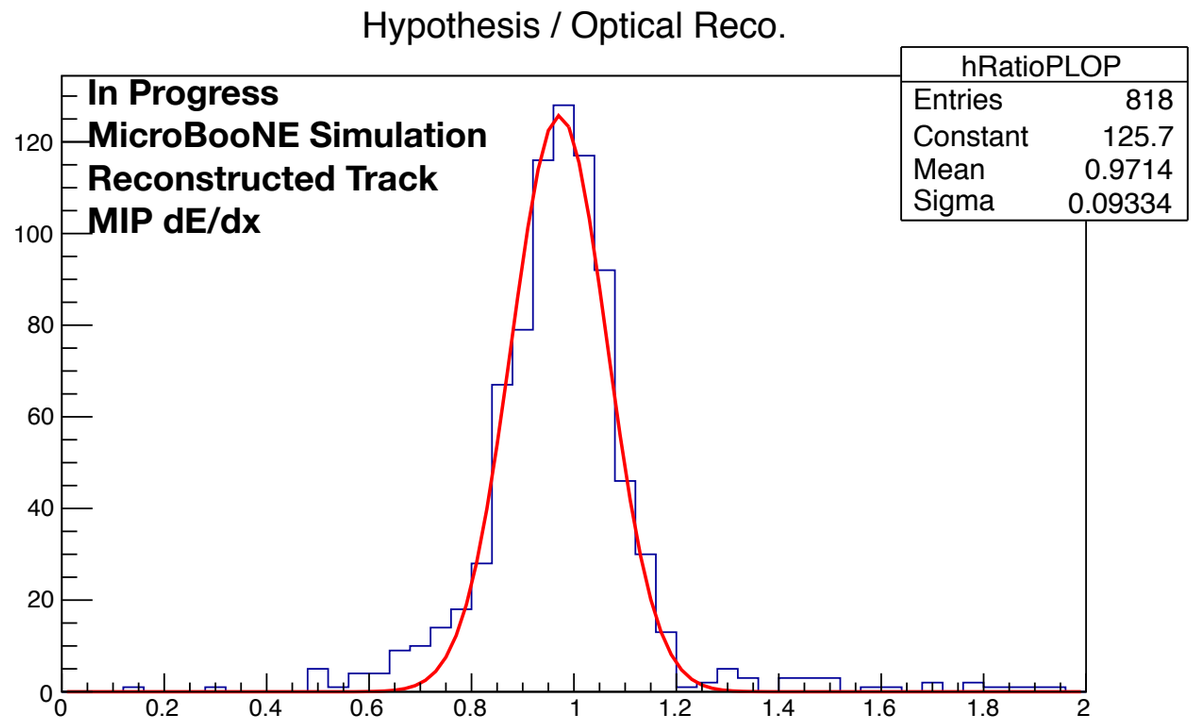
Light Prediction —Reconstructed Track

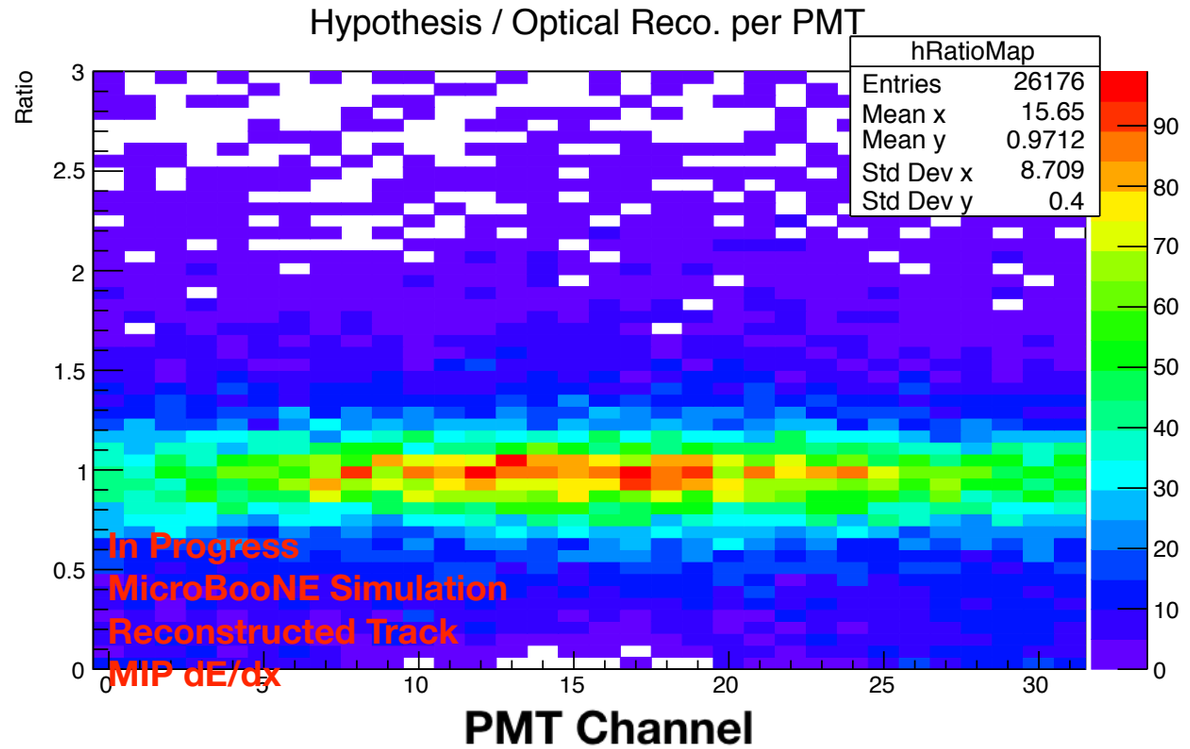
- Factor in light predictions between MC track and reconstructed tracks are disentangled into two:
  (1)Deviation between real dE/dx calculated in MC and MIP in reconstructed tracks
  (2)Inefficiency introduced by track reconstruction

- Knowing the factor of real dE/dx is small, we can apply the light prediction algorithm to reconstructed tracks,

- Same comparisons:
  Top: ratio of total amount of light between hypothesis and optical reconstruction;
  Bottom: scan of comparisons across all PMT channels,

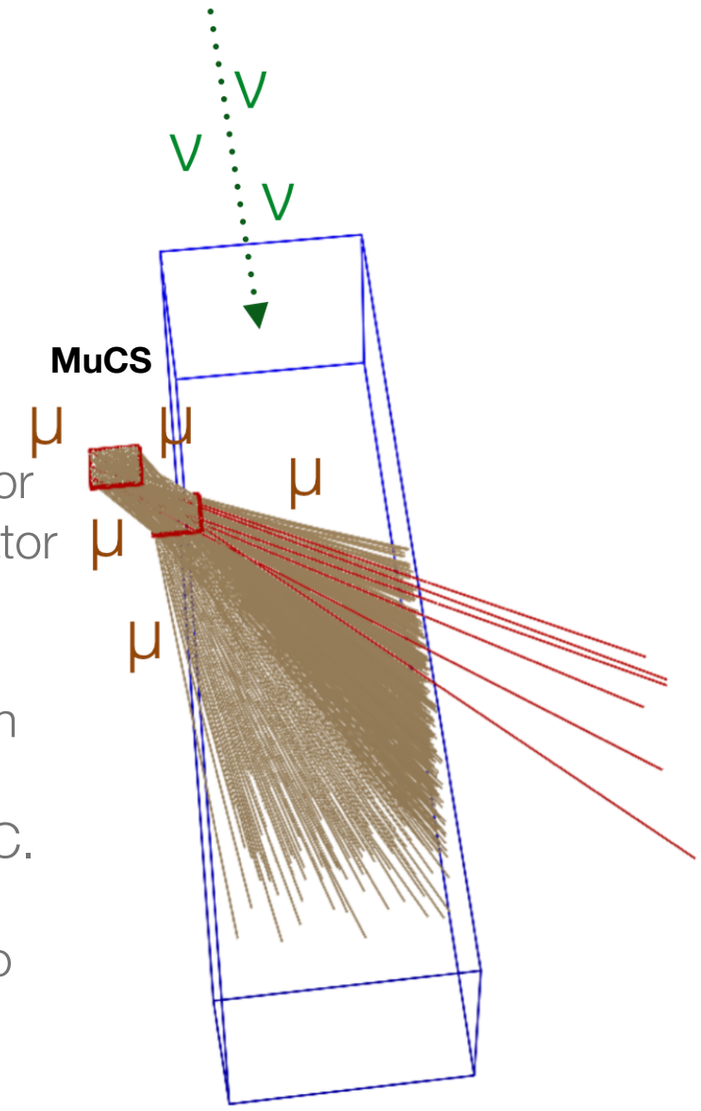
- To conclude, inefficiency of light prediction from constant dE/dx and track reconstruction introduces 1% more light than optical reconstruction.

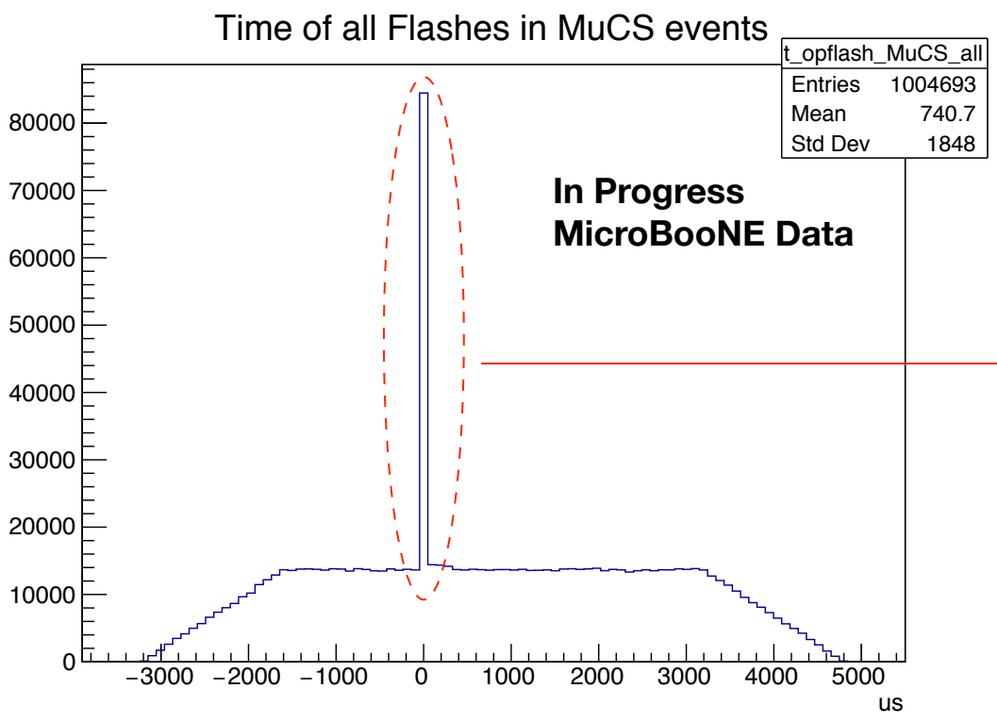


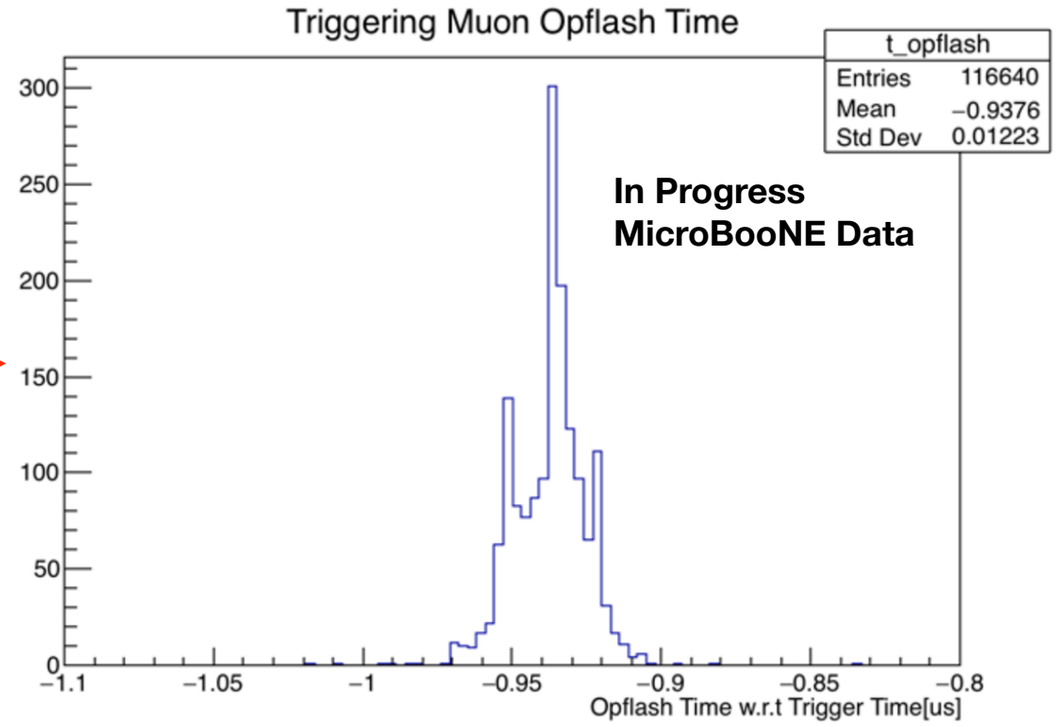


Muon Counter System

- Muon Counter System(MuCS) is a prototype of a full cosmic ray tagger system for MicroBooNE. It consists of two identical muon detectors made of plastic scintillator strips.
- MuCS events are coincident energy depositions by cosmic muons on both muon detector panels. In these events, optical flash of triggering muon always comes right before event time 0 due to delay in the Cu cable connecting MuCS and TPC.
- Capable of knowing delay from T0, MuCS events provide a perfect test ground to do a one-track-to-many-flashes matching.





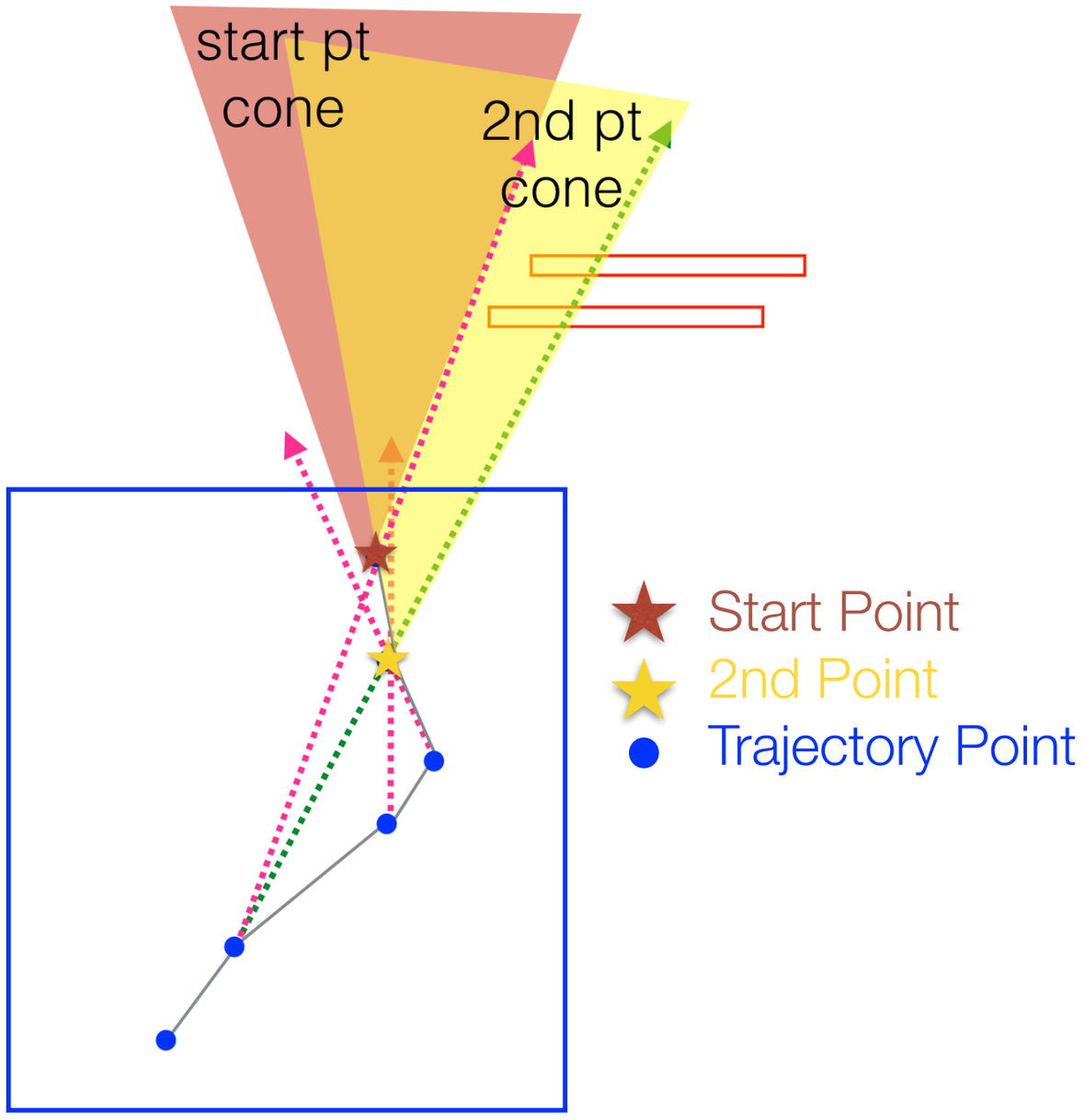


Tagging MuCS Tracks

- MicroBooNE TPC is placed at surface and is exposed to a rain of cosmic rays. There are an average of 20 cosmic muon tracks in one MuCS event. But only one or a small chance of two muon tracks actually fire the MuCS triggers.

- To launch a one-to-many matching, we need to tag the MuCS events.

- Selection Metric:
  (1)Identify intersections of back-projected tracks and MuCS
  (2)MuCS re-centering and padding. MuCS is expanded and moved to 'ideal' position based on track tagging efficiency.



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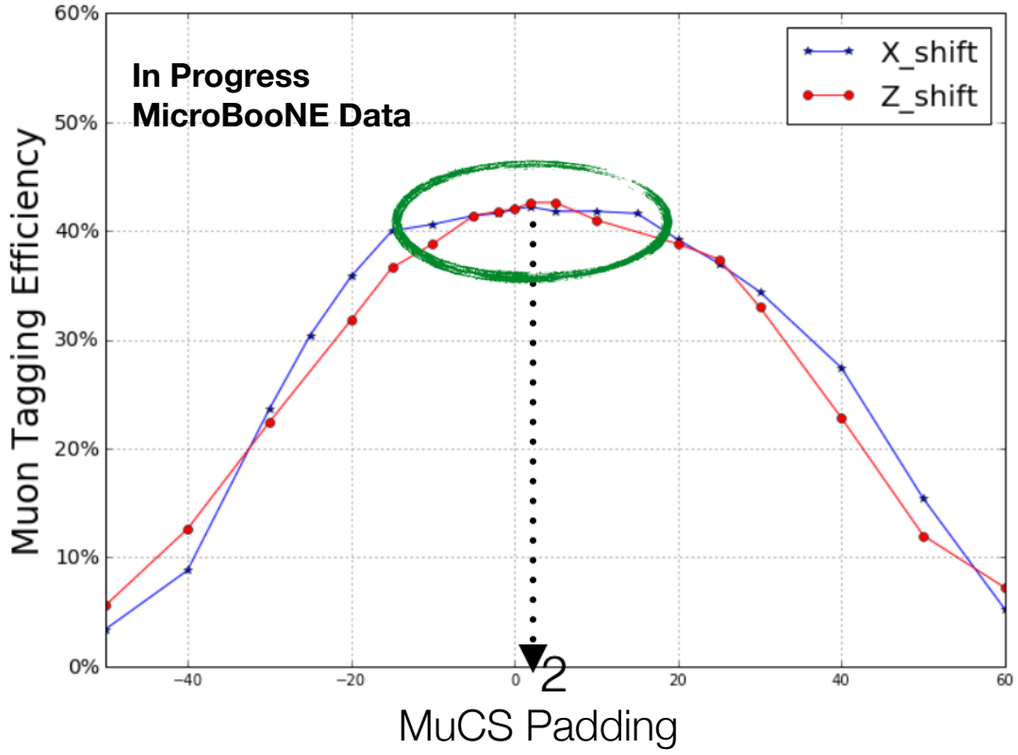
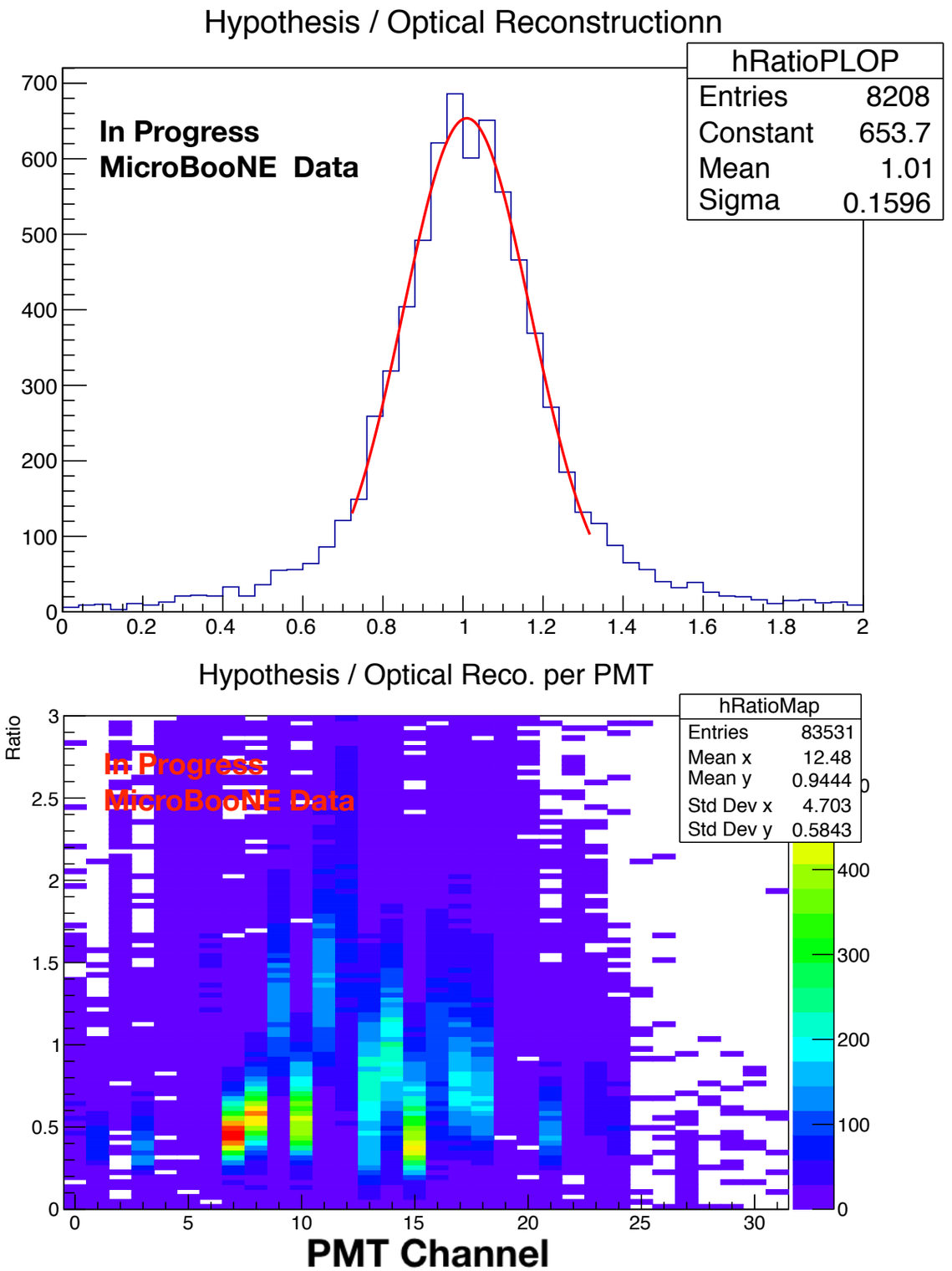


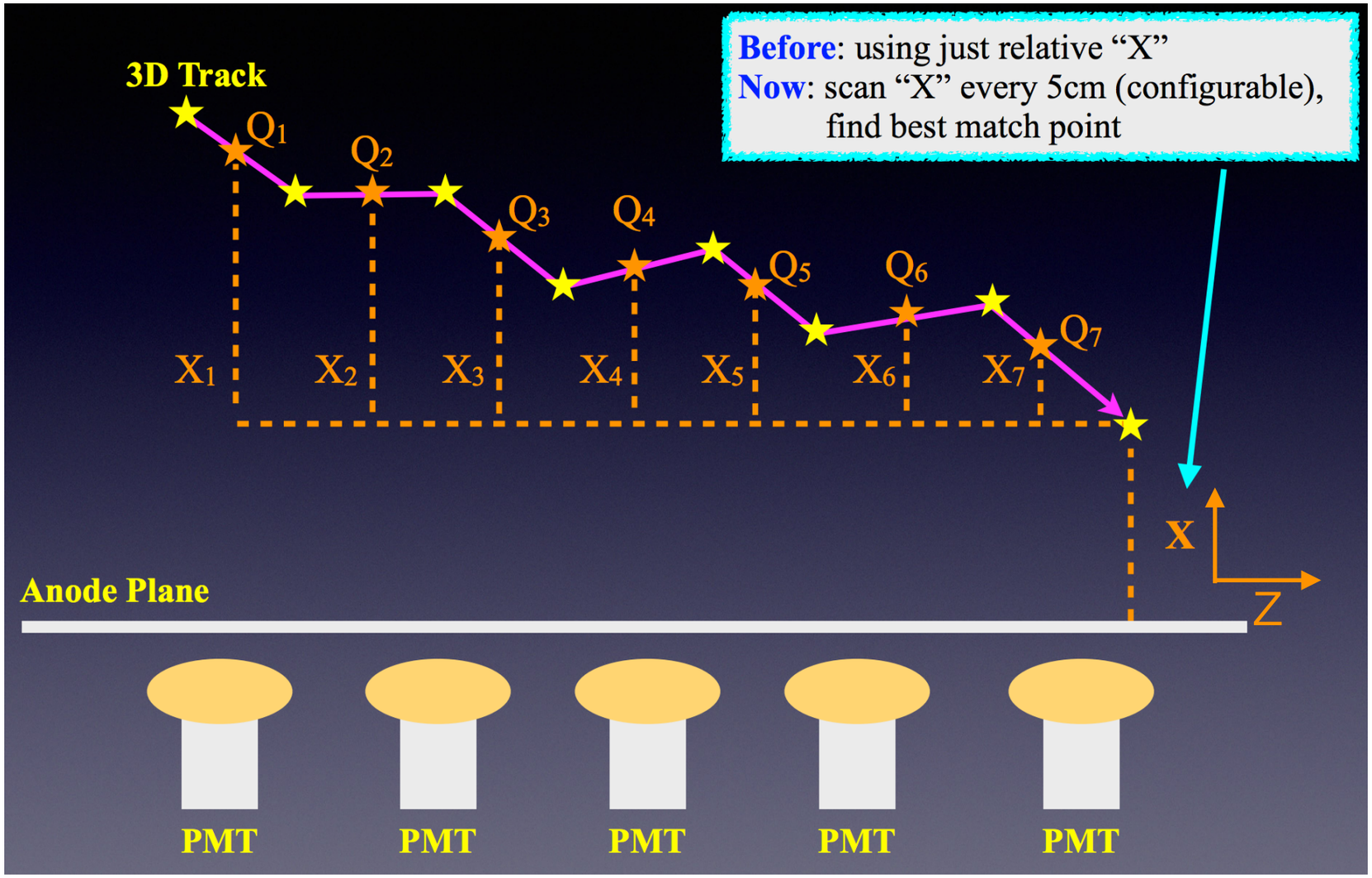
Light Prediction —MuCS data

- MuCS tagged tracks are treated as muon MIPs and the output is compared to light found right before T0 in [-1,-0.9]us.
- PMT gains vary over time. Another normal run near MuCS run is selected to calculate the SPE response function to calibrate PMT gains.
- We compare hypothetical and reconstructed lights in the same way as we did for MC data. The calibrated ratio of total amount of light between hypothesis and optical reconstruction is well peaked even though the channel-wise scan shows some deviations.



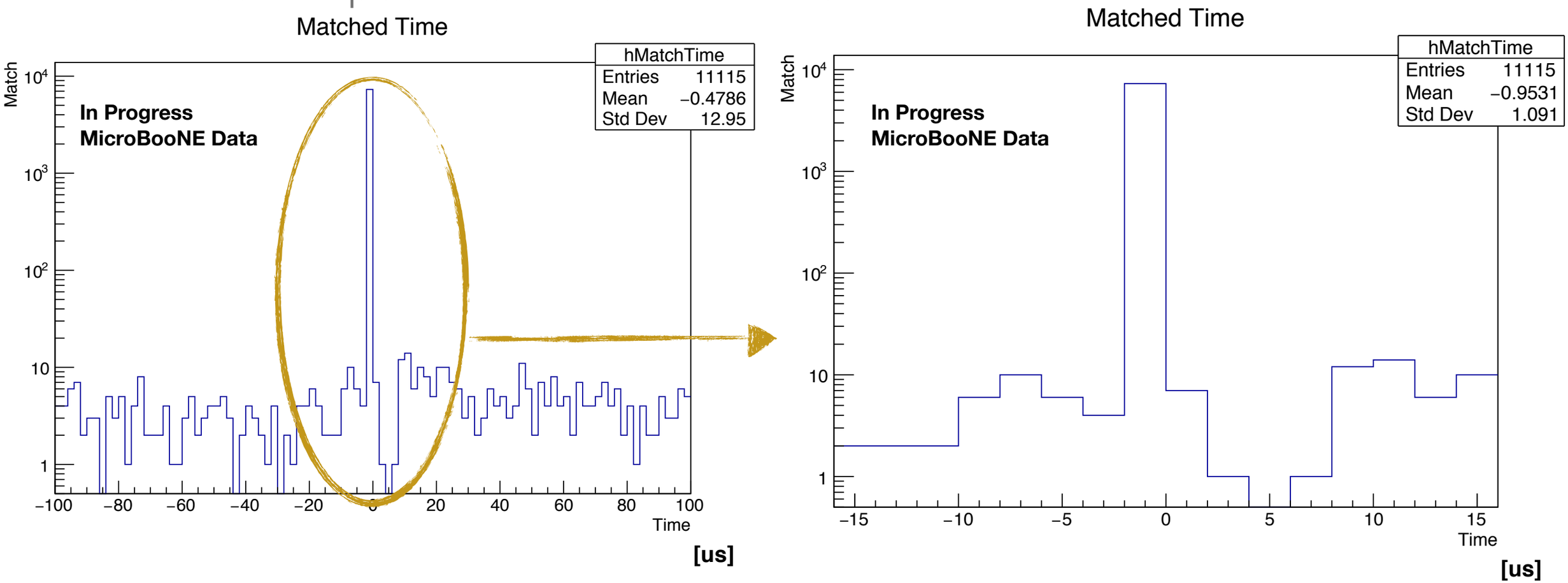
Flash Matching Metric

- The current flash matching method shifts trajectories away from PMT by a step of 5 cm.
- Charge weighted z position for each step is calculated and compared to the charge weighted z position derived from optical reconstruction.



Flash Matching in MuCS

- Knowing the time delay between MuCS flashes and T0, we know where we should expect the matched flashes.



- On average there are ~60 flashes in a MicroBooNE event. We need to find out the one flash corresponds to that triggering Muon.

- Plot above shows time of matched flash. 7k out of 11k MuCS tagged tracks are matched to the their flashes in time [-2,0]us.

Summary

- MicroBooNE has performed a preliminary study about its optical models in MC and a specific data stream—MuCS.
- The one-to-many flash matching test is the first step towards a full cosmic muon removal method and it gives us confidence that neutrino interactions can be revealed by their flashes.

Thank you !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ENERGY


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μBooNE


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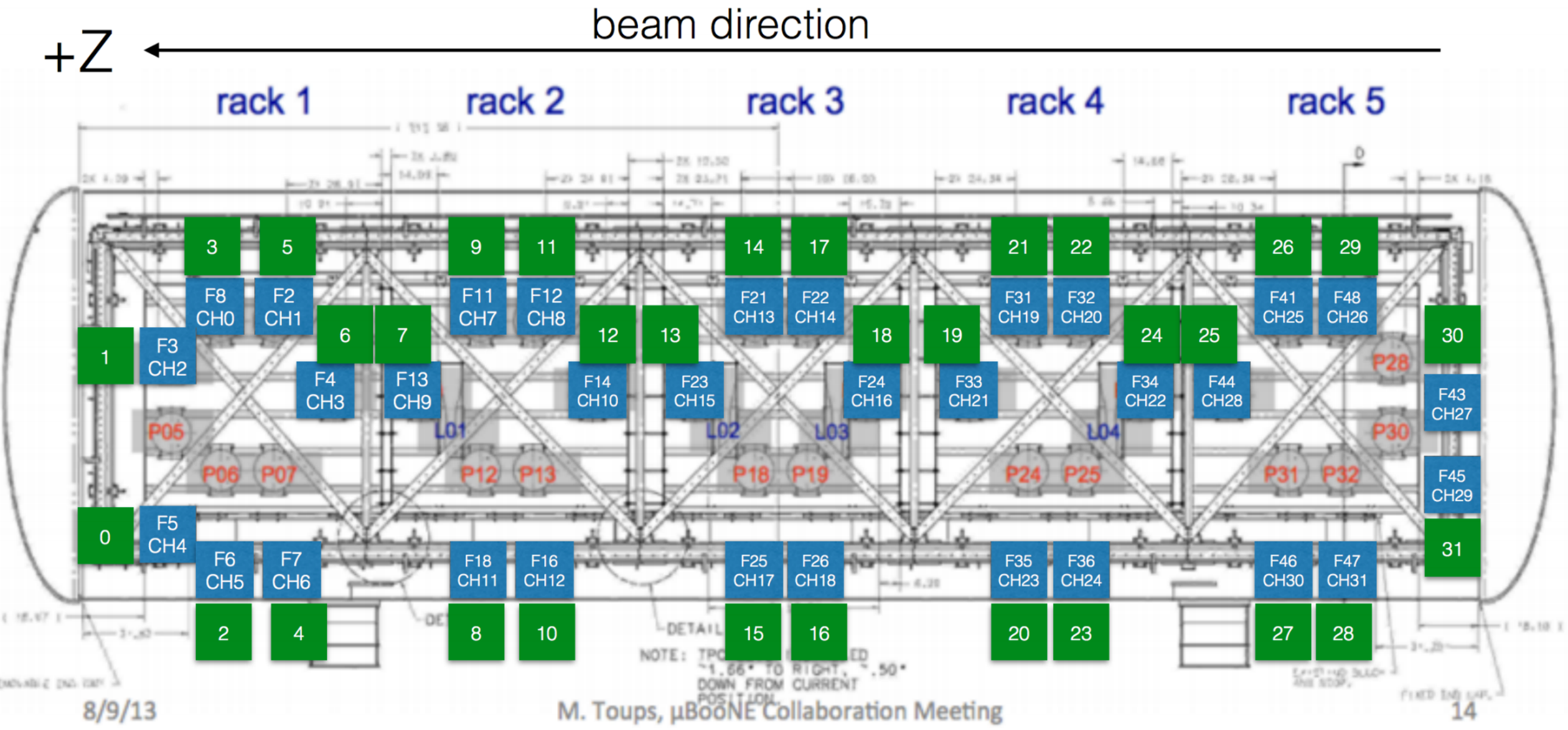
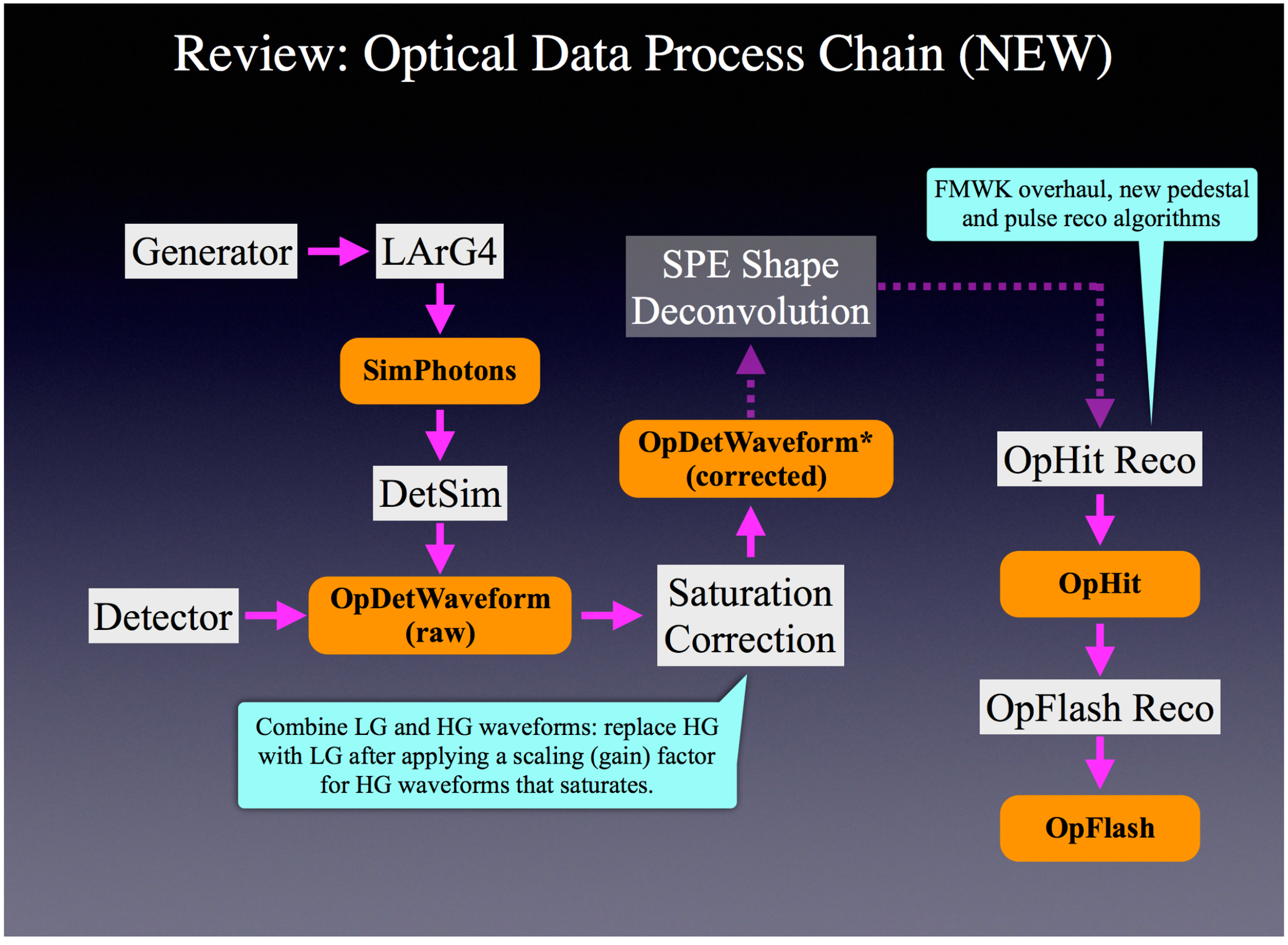
BackUP

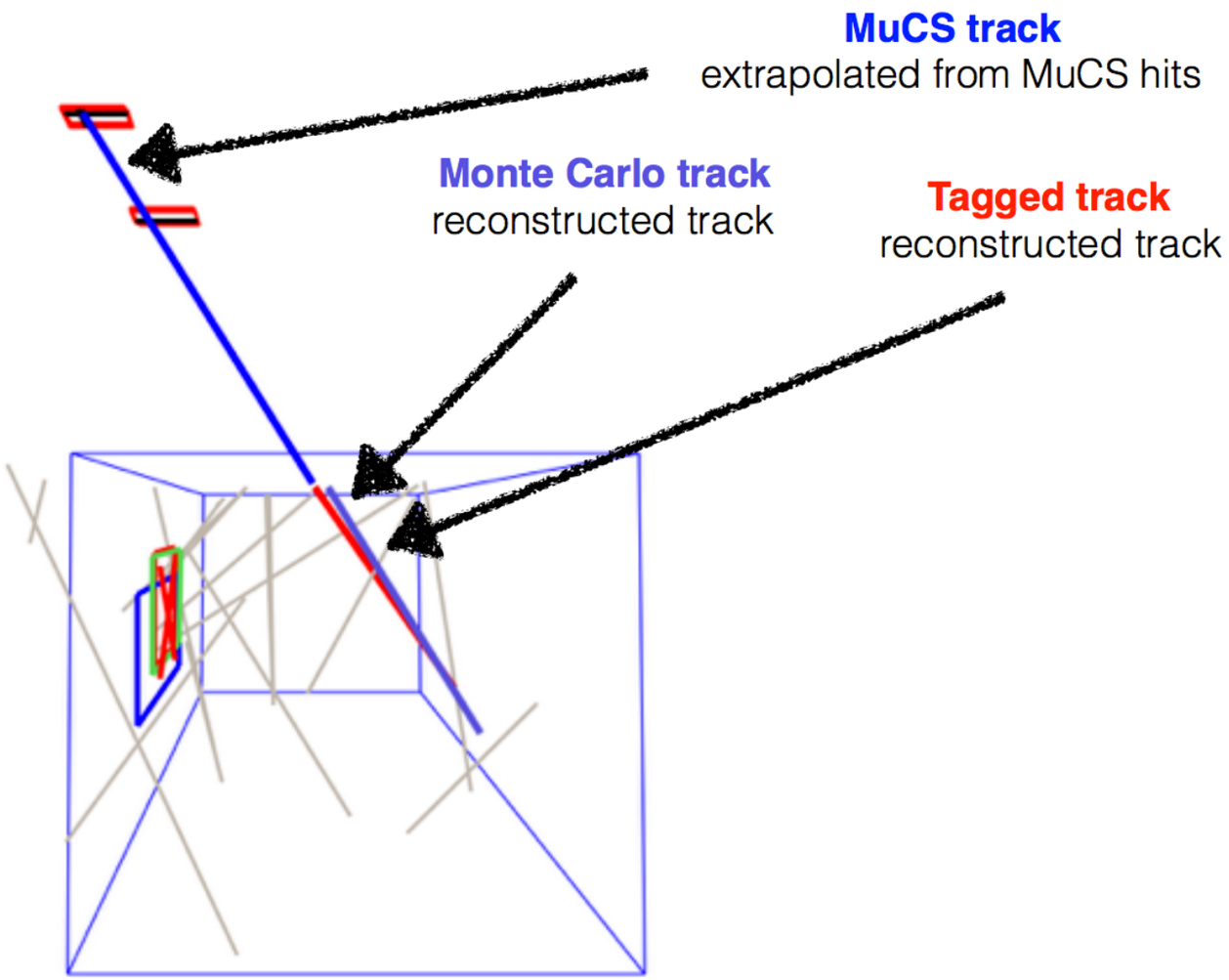
PMT Map


+Z
beam direction
rack 1
rack 2
rack 3
rack 4
rack 5
3
5
9
11
14
17
21
22
26
29
F8 CH0
F2 CH1
F11 CH7
F12 CH8
F21 CH13
F22 CH14
F31 CH19
F32 CH20
F41 CH25
F48 CH26
1
F3 CH2
6
7
12
13
18
19
24
25
30
F4 CH3
F13 CH9
F14 CH10
F23 CH15
F24 CH16
F33 CH21
F34 CH22
F44 CH28
F43 CH27
P28
P05
L01
L02
L03
L04
P30
P06
P07
P12
P13
P18
P19
P24
P25
P31
P32
F45 CH29
0
F5 CH4
31
F6 CH5
F7 CH6
F18 CH11
F16 CH12
F25 CH17
F26 CH18
F35 CH23
F36 CH24
F46 CH30
F47 CH31
2
4
8
10
15
16
20
23
27
28
DETAIL
NOTE: TPC
~1.66" TO RIGHT, ~.50"
DOWN FROM CURRENT
POSITION.

Optical Reconstruction



Why building a cone



SPE responce